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INFECTION AND DISINFECTION

BY

ROBSON ROOSE, M.D.

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ROBSON ROOSE, M.D., F.C.S.

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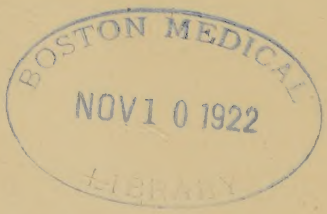

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INFECTION AND DISINFECTION.

THE enormous variety of subjects contained in medical literature necessitates the use of a corresponding number of terms, the majority of which have a certain and well-known meaning, but it would be difficult to find two words more wanting in the element of precision and more loosely used than those placed at the head of this article. The general public, indeed, solve all difficulties by connecting with the word "infection" the idea of something "catching," *i.e.* something that can be propagated from one person to another, and disinfection is correspondingly regarded as the means whereby such propagation can be hindered. It must be admitted that this simple view is quite correct so far as it goes. It of course disregards all questions as to the nature of infection, and the reason why some diseases spread from person to

person and others do not, and it accepts without doubt the belief that disinfection is generally attainable, and by comparatively simple means. In cases especially where the use of some well-advertised material is found to neutralise or mask an unpleasant odour, the completeness of the disinfection is looked upon as absolutely certain.

In medical writings the confusion has been still further increased by the use of the words "contagion" and "contagious" in describing those diseases which were considered to spread from one person to another by contact. "Infection" and "infectious" were limited to the cases in which the poison of the disease was supposed to be conveyed by the atmosphere from the sick person to those at a greater or less distance from him. Accordingly, we used to hear of a disease being contagious but not infectious, and *vice versâ*. The distinction is, however, a purely artificial one, and is not sustained by facts, for many of the contagious diseases can be propagated indirectly, that is, without actual contact between the person who yields the poison and the person who receives it. Take, for example, diphtheria: it assuredly spreads by contact, and is therefore contagious, and no less positively is the

poison capable of being disseminated through the atmosphere and infecting those who inhale it. So, too, with small-pox. If its virus be introduced under the skin of a person unprotected by vaccination or a previous attack, he will almost certainly suffer from the disease, and the same result would follow were such a person to be in close attendance upon a small-pox patient. In the latter case, the poison floating about in the atmosphere would get into the system through the lungs, and this is practically just as much an example of *contact* as if the poison were artificially introduced through the skin. It is therefore better to consider the terms "infection" and "contagion" as practically synonymous, and they will be so used in the remarks that follow.

To show what is implied by an infectious disease, let me take a typical example and contrast it with another disorder well known to be non-infectious. A young adult, previously in good health, is suddenly attacked by such symptoms as chilliness, soreness of throat, and evidences of derangement of the stomach. There is nothing characteristic about these symptoms, but let us suppose that on the following day there is high

fever, dryness of skin, headache, giddiness, etc., and that in a few hours a scarlet rash appears, first on the chest, and then spreads over the body. All the symptoms become worse, and for ten or twelve days the patient is very ill. After this period, in favourable cases, a change takes place for the better, the rash dies away and all the other symptoms gradually subside. In from three to six weeks, supposing that there are no complications, the patient regards himself as well. Such, in a few words, is the course of a mild case of scarlet fever, which may be considered as a typically infectious disease. Now suppose that our patient is treated in a house where there are several other young people who have never suffered from the disease. We know from experience that unless the most minute precautions are taken, the majority of these persons will exhibit similar symptoms. It is also well known that if any of these patients, supposed to have partially recovered from the disease, change their place of abode and go among other friends, the latter will run great risk of being attacked, and that the disease may thus spread *ad infinitum*. This capacity of propagation, the possession of which is as certain as anything can possibly be,

suggests the inquiry as to the manner in which the original patient of our series became infected. He in his turn must have taken the disease from some one else, but it is quite possible that he has never been within a mile of a scarlet fever patient. In many such instances it is impossible to get any clue to the original case, but it sometimes happens that evidence is forthcoming to the effect that days or weeks, or even months before, a person convalescent from the disease has occupied a room of which our patient was afterwards a tenant, or that some article of clothing which once belonged to patient number one has been handled or worn by the person whose case we are considering. It is evident that there must often be great difficulties in prosecuting such an inquiry.

Let us now take an example of a non-infectious disease, and notice how it contrasts with the one we have just described. A young adult, previously in good health, becomes sensible of a feeling of heat alternating with chilliness and perhaps shivering, and slight pains in the limbs. In a day or two there is more or less fever and thirst, and some of the larger joints are swollen and very painful, while the skin covering them is much reddened. The pain

and fever are the principal symptoms, but there are often others, a description of which is unnecessary for our present purpose. The complaint lasts an indefinite time, but even in the absence of treatment usually subsides within six weeks. Such, in a very few words, is the course of rheumatic fever or acute rheumatism.

These two diseases, scarlet fever and rheumatic fever, have much in common, but there are sharp points of difference between them. In both fever is a prominent symptom, and in addition to the display of local symptoms the whole system is evidently affected. The differences, however, are still more important. Scarlet fever is eminently infectious. The air which surrounds the patient becomes contaminated and highly charged with the poison, and persons breathing it run great risk of becoming affected. In a case of rheumatic fever, although the secretion from the skin is generally very copious and peculiar in character, so that the sense of smell is strongly appealed to, there is no such risk ; the disease cannot be conveyed from the patient to those around him, however close the attendance and however defective the ventilation of he room. Infection from a previous case is there-

fore never thought of in connection with rheumatic fever, though the actual nature of the poison which causes the disease is as yet unknown. The attack is often excited by exposure to cold and wet, circumstances which play no part in the causation of scarlet fever. There is at least one more important difference between the two diseases: scarlet fever very rarely indeed occurs a second time in the same patient, and the symptoms never become chronic; rheumatic fever, on the other hand, is very prone to recur, and in not a few cases the original attack merges into a chronic state of suffering, which may continue for months or even years.

I have taken scarlet fever as a representative of the class of infectious diseases the cause of which is the contamination of the system by some specific poison, and I have sketched in a few words the main symptoms which result. For our present purposes the important points are the contagious or infectious character of the disease, and the proofs that the contagious material multiplies within the system which it has invaded, and from which it sallies forth in quest of other victims. There are, unfortunately, not a few diseases be-

longing to the same category as scarlet fever, the principal being small-pox, measles, typhus, influenza, whooping-cough, diphtheria, typhoid, and cholera. With regard to all these it may be stated that they are quite separate and distinct as regards causation. A case of scarlet fever never gives rise to small-pox in those exposed to infection, neither does any one of the above diseases ever pass into another. There are other subordinate distinctions: the poison of scarlet fever, contained presumably in detached particles of skin, clings for months to articles of clothing, especially woollen ones; that of small-pox may be collected from the eruption and preserved for years between pieces of glass; that of typhus is easily rendered innocuous by free ventilation. All these peculiarities — and many more might be cited—point to important differences in the nature of the infectious materials.

What this infectious material really is has often been keenly debated since medicine became a science, and at the present time is the question which most closely occupies the minds of medical investigators. Merely to enumerate the inquiries and to describe the experiments and the theories based thereon would fill many volumes;

but it is not to be wondered at that this subject should have excited so much attention when we reflect upon the prevalence and fatality of the diseases in question, and upon the comparatively slight influence which treatment exercises upon their course. On the other hand, experience clearly shows that their prevention is not only possible, but in some cases easily accomplished. The knowledge of the causes of these diseases would indicate the proper preventive measures, or at any rate the direction which such measures should take, and hence a discovery of the cause in any given case at once yields practical results. When we know what causes infection we can apply disinfection with every prospect of success. Without such knowledge, success if attained must be accidental rather than otherwise. The nature of the contagious agencies and the medium through which they spread are the most important points in connection with the subject of infection.

There is strong evidence in support of the view that these contagia are actual living things. Formerly the opinion was universally held that infectious diseases were caused by foul air, and the effluvia connected with putrid decomposition were

regarded as a sufficient cause for the development of fever, small-pox, etc. It cannot be denied that gaseous matters, notably sulphuretted hydrogen, may act as poisons and cause many serious symptoms, but it has never been shown that infectious diseases originate in this manner. It is contrary to all that chemistry teaches us that sulphuretted hydrogen or ammoniacal vapours inhaled by the lungs should increase within the body and cause it to become a centre of infection; and we know likewise that ordinary poisons, *e.g.* arsenic or morphia, fatal as their effects may be to one individual, have no power of increase and propagation after being once taken. It is therefore evident that the poisons of infectious diseases must be something of an entirely different nature. We know that they multiply in the system to an almost infinite extent, and that every one of the myriads of atoms thus developed is as potent for evil as the atom from which it originated. The possession of this and other properties clearly indicates that the contagious agencies are independent living organisms capable of growth and reproduction. It has long been known that certain diseases of the skin—*e.g.* ringworm—are caused by the presence of parasites

which very rapidly increase, and can be easily recognised under the microscrope.

In the case of some three or four of the infectious diseases it would seem that the poison has really been discovered. On examining vaccine matter, the contents of the pocks in small-pox, and discharges in glanders, the microscope shows a vast number of infinitely minute particles, which appear as glistening points. Some of these are even less than the fifty-thousandth of an inch in diameter, and it therefore follows that very high powers are necessary for their detection. Such particles, obtained from vaccine lymph, have been washed in water; the water when inoculated did not produce any effect, but the washed particles were found to have retained their potency. It seems fair to infer that the contagious agents of the other infective diseases would resemble in their physical characters that of vaccine, and the nature of such particles is the important problem that offers itself for solution. They are supposed by some, and notably by Dr. Beale, to be of animal origin, and to consist of elementary living matter, termed *bioplasm*. Such particles may be easily transferred from an infected to an uninfected

organism, in which they will manifest their own specific powers, and grow and multiply almost indefinitely, exciting in their new home a series of changes resembling those which characterised their presence in the one from which they were derived. This account is certainly correct as regards the virus of vaccine, but it does not precisely define the nature of the particles or tell us anything of their origin. Dr. Beale, however, states that particles of contagious bioplasm are not generated in the organism of the infected animal, but are introduced from without, and were originally derived by direct descent from the bioplasm of the body of man or animal. He regards them in fact as particles of degraded bioplasm. This theory is not in favour, or rather is not fashionable, at the present time. One objection to its validity is constituted by the fact that particles of living animal matter die very rapidly after they have escaped from the body, whereas many contagious germs preserve their vitality and capacity for evil for a very long time.

Another theory which was promulgated some twenty years ago was to the effect that the contagious particles are of the nature of those low

vegetable organisms which are termed *fungi*. This view gains support from the manner in which these bodies increase in number when planted in a suitable soil, and the power which they possess of decomposing many organic substances. The fact, already referred to, that several diseases of the skin and hair in men and animals are undoubtedly due to fungi, also tends to recommend this theory. Recent experiments, however, have shown that these organisms, capable as some of them are of growth and development on the *surface* of the body, do not possess the power of growth and reproduction *within* the body, and it is therefore unlikely that they should be the causes of disease in which the system is charged with poisonous materials.

A third theory is one which is extremely popular at the present day, advocated as it is by investigators of the highest repute. It is almost needless to say that I refer to the view which credits certain minute organisms, termed *bacteria*, with the power of causing the infectious diseases —that is, with being in themselves the poisonous agents. So firm is the hold that this view has obtained that "disease-germs" and "bacteria"

are used as though they were synonymous terms. It is, moreover, probable that more experiments have been made with reference to bacteria than on any other subject whatever.

The term "bacterium" signifies a rod, and many of these organisms are minute rod-shaped bodies. They or their germs are very widely diffused throughout nature; they swarm in the air and in water, especially if containing organic matter, and are likewise found in great numbers within the bodies of men and animals. Any one who possesses a microscope with a magnifying power of five hundred diameters can readily examine a very common form of bacterium. It is only necessary to take a glass of ordinary water from a spring or river, and to leave it in a warm room exposed for some days to the air. A thin coating, looking like a deposit of fine dust, is formed on the surface of the water; this dust consists of myriads of bacteria, which are readily seen when a drop of the water is examined. The bacteria are found to be in several stages of transformation: some are in long jointed rods, others represent one or more detached portions of these rods, and others appear as extremely minute

rounded particles. The rods are capable of movement, and they are seen to wriggle through the fluid like small eels or snakes. The minute rounded particles are the spores, which eventually become rod-shaped bodies. These and other organisms are found in great abundance in an infusion of hay, set aside for some days till it has become turbid.

The peculiar interest connected with these simple experiments is due to the fact that minute organisms closely resembling those just described are found in the bodies of patients suffering from acute infectious diseases, and the question naturally arises as to the relation which exists between the organisms and the symptoms. Are the former the cause of the latter, or is their presence a mere coincidence? Another suggestion is that their presence is the result of the disease. If the symptoms are really caused by the presence and action of the bacteria, it would follow that differences must exist between the organisms found in different diseases. Great and manifold difficulties attend such investigations; it is sufficient here to notice the extreme minuteness of the organisms, necessitating the use of the highest

powers of the microscope for their detection. Moreover, as already stated, bacteria are found in large numbers in the bodies of healthy persons, and some of these organisms very closely resemble, if indeed they are not identical with, those that have been found in connection with severe infectious diseases. It is hardly conceivable that minute organisms which abound, for example, in the mouth and give rise to no changes, should be capable in other parts of causing the most serious symptoms.

In order to prove that a micro-organism is the real cause of a disease, at least three conditions must be fulfilled. In the first place, the same species of micro-organism must be invariably found in the parts affected by the disease in question, at any rate during the early stage, and in no other affection. Secondly, the organism must be cultivated apart from the body in which it has been found, so as to make sure that it has been separated from all other morbid materials to the presence of which the disease might possibly be due. Thirdly, when the organisms thus cultivated have been introduced into the body of an animal capable of being attacked by the disease, similar symptoms

ought to be set up, and the same micro-organisms should be found in the newly affected animal. If, in testing any given disease, these conditions are fulfilled, it is scarcely possible to doubt that the micro-organisms are the cause; they certainly cannot be the result. It is fair also to argue from diseases in which the conditions are fulfilled, that others in which, owing to circumstances, the tests cannot be properly carried out, are due to similar causes.

Very strong evidence is forthcoming in support of the theory that micro-organisms are the cause of infectious diseases. Horned cattle and sheep are subject to a disease termed anthrax, or splenic fever, and more than thirty years ago, minute rod-shaped bodies were found in the blood of animals which had died from this disease, which is also communicable to man. The significance of these rods was suspected only after Pasteur's researches into the part played by minute organisms in fermentation. Guided by these discoveries, Davaine inoculated healthy animals with blood from those diseased, with the result of producing similar symptoms, while myriads of organisms were found in the bodies of those animals which had been

inoculated with a very minute quantity of blood. The symptoms are very characteristic, and the disease at one time caused an enormous mortality among cattle in France. By the opponents of the bacterium hypothesis it might of course be urged that in the inoculation experiments other morbid materials were simultaneously conveyed, and that the transmission of the disease was due to their presence. To meet this objection and to fulfil the second condition laid down in the last paragraph, experiments for cultivating the organisms were set on foot in the following manner. A drop of blood taken from an animal that had died from anthrax was put into a glass flask containing an infusion of yeast, which had been carefully treated and proved to be free from organisms. In twenty-four hours the liquid, previously clear, was seen to be full of very light flakes, which, when examined under the microscope, were found to be masses of organisms resembling those contained in the blood. A drop taken from this first flask was added to a second and produced the same effect, and a drop from this was added to a third, and so on till a tenth flask was thus charged with organisms. In this way the organisms were enor-

mously multiplied and completely freed from the admixture of any other substance. Yet when a drop was taken from the twentieth or even the fiftieth flask of such a series and inserted under the skin of a sheep it caused anthrax or splenic fever, attended by the same symptoms as those produced by the drop of blood taken from the first animal. It is impossible to conceive of any clearer proof that the organisms are the sole cause of the disease. So crucial a test, however, cannot be applied in every case, for many of the infectious diseases which are the scourge of mankind do not affect the lower animals, and it is therefore impossible to make trial of the organisms found in connection therewith. Besides anthrax, there are other infective diseases in animals which have been proved to be due to bacteria, and these facts strongly support the belief that the infectious diseases of mankind are due to the invasion of similar organisms. It is, however, impossible as yet to dogmatise upon this subject. There have already been too many assertions and inferences drawn therefrom which have turned out to be unwarranted. It is comparatively easy for skilled observers to detect the presence of micro-organisms,

and whenever uniformity of appearance is demonstrable in connection with a given disease a decided addition has been made to our knowledge. For reasons above given, the next point, viz. the determining whether the organisms are the cause of the disease, is surrounded with great difficulties. The discoveries, however, with regard to splenic fever strongly support the view that bacteria are the efficient agents of contagious diseases.

Space will not permit me to do more than allude to the various theories that have been advanced with regard to the manner in which these tiny organisms produce disease. It was at first thought that they acted like parasites, and exhausted the system during their development. It is now, however, more commonly believed that the organisms elaborate a special ferment or poison, which, when produced in sufficient amount, gives rise to the symptoms of the disease.

One of the most valuable results of the study of these organisms is the discovery that by cultivation the virulence of some, at least, can be so mitigated that when inoculated they produce only slight and non-fatal symptoms, the development of which in a given animal is nevertheless

protective against future attacks of the original disease. By cultivating the organisms of splenic fever at a temperature of 108° it is found that filaments are produced but not spores, and that by repeated cultivation this growth becomes altered as regards its properties of causing disease. When inoculated it sets up a mild form of splenic fever, not dangerous to life, but perfectly protective against subsequent inoculation with the otherwise poisonous organisms. This discovery is worthy of being classed with that of vaccination as a protection against small-pox.

With regard to the channels through which the contagious organisms are spread, a few words will suffice to state what is known on this point, which is intimately connected with the subject of disinfection. Air and water are the chief media for the propagation of infectious disease. In the case of scarlet fever, which has been taken as the type, the scales detached from the skin and similar tissues from the throat contain the germs of the disease, and these find their way into the atmosphere and are received into the lungs. They attach themselves also to articles of clothing and furniture, and are thus often carried to long

distances. The tenacity with which such contagia adhere to woollen articles is very remarkable. Sir Thomas Watson relates the following instance: A house in which several persons had been attacked by scarlet fever was left empty for a year. When the family returned, a drawer in one of the bedrooms resisted for some time attempts to pull it open. A strip of flannel had got between the drawer and its frame, and had made the drawer stick. This piece of flannel the housemaid put playfully round her neck. An old nurse who was present, recognising it as having been used as an application to the throat of one of the subjects of scarlet fever, snatched it away and burnt it. The girl, however, soon sickened with the disease. In the cases of cholera and typhoid fever, the discharges from the patient find their way into water, which thus becomes the channel by which the diseases are propagated. Food, too, may become similarly contaminated. Milk, for instance, has been often known to convey the poisons of typhoid fever, of scarlet fever, and of diphtheria. In the case of the first, the contamination has been probably due to adulterating the milk with foul water contain-

ing the disease-germs, but it may have arisen in some cases from the typhoid emanations having been absorbed by the milk. The poisons of scarlet fever and diphtheria were probably transmitted to the milk from the skins and throats of persons employed in the dairy, and recently convalescent or scarcely recovered from attacks of these diseases. The germs of certain other infectious diseases find their way into the system through abraded surfaces of the body.

The fatal character of many infectious diseases, and the ease and rapidity with which they spread and attack large masses of the population, are sufficient to account for the endeavours that have been made since very early times to arrest their progress. As in many other matters, practice has preceded science, and centuries before the vaguest ideas were entertained as to the nature of the diseases which seemed destined to be the scourges of mankind, efforts were made to stamp them out. As might be expected, many of these efforts were of the rudest description, but the earliest of them aimed at the object which the most modern science also seeks to achieve, viz. the destruction of the contagious material. The

term "disinfection" first occurred in literature towards the end of the last century. A French writer, Morveau, in 1801, published a work on "The Disinfection of the Air," but the word was used somewhat earlier by a few English writers.

The most ancient method consisted in destroying by fire everything that had been in contact with the source of infection, the idea, no doubt, being that as fire consumes what is visible, it likewise destroys what is invisible. It is possible that the practice of burning the dead was in a measure based upon the conviction that a source of danger to the living was thus got rid of. The thirteenth chapter of Leviticus contains the most minute directions for disinfecting cases of leprosy; destruction of suspected articles by means of fire, the copious use of water, and isolation of the leper, are the means prescribed. Inspection by the priest was to decide as to the efficacy of these measures. Among the Egyptians and certain Asiatic peoples, the fumigations used by the priests in exorcising disease were probably neither more nor less efficacious than similar processes in vogue at the present day in some European countries.

In the growth of ideas with regard to the causes of infectious diseases, the theory gradually took shape that the infecting matters were formed as a result of the processes of decomposition, and as these processes are generally attended with the development of more or less unpleasant odours, it seemed only natural to assume that the causes of the latter were also the causes of disease. Instead of regarding foul emanations as generally mischievous, the idea was entertained that there was something quite specific about them, and accordingly we find that attempts to mask or neutralise them were regarded as the best methods of checking the spread of infectious diseases. Deodorisation came to be considered as equivalent to disinfection. The idea was the more welcome inasmuch as it could be carried into effect without destroying property and without much difficulty. The attempt was certainly in the right direction, for the destruction of noxious agencies was the object in view. Unfortunately the means employed absolutely failed to effect their purpose, and belief in their efficacy caused very mischievous results, viz. a sense of false security and neglect of ventilation and cleanliness as regards sick persons

and surrounding objects. In fact, the confident adoption of deodorants as a means of checking the spread of infectious diseases, was a decidedly retrograde step as compared with the use of fire for destruction and of water as a purifying agent.

Chlorine gas was the deodorant which came into very general use at the beginning of the present century. It was freely employed in hospitals, both civil and military, in prisons, workhouses, etc., and was supposed to be efficacious against fevers, cholera, and small-pox. Whenever its characteristic odour could be perceived, danger of infection was no longer feared. Persons carried about with them small flasks containing chemicals which generated this gas, and inhaled a little when they considered themselves exposed to risk. It soon, however, became evident that these precautions were useless; but even so recently as 1866, during the war between Austria and Prussia, it was thought sufficient to distribute saucers containing chloride of lime throughout the military hospitals, while only feeble efforts were made to ensure cleanliness and other important sanitary requirements. In

order to act as a real disinfectant, chlorine must be employed in a very different manner. The terrible mortality after surgical operations and severe injuries, a feature of which was that a large majority of patients died with symptoms of blood-poisoning, showed the futility of such attempts at disinfection.

In spite, however, of many similar failures, deodorisation has been almost universally regarded as the main object to be accomplished, and other chemical agents have been used in order to combat the gaseous products of decomposition. This object could certainly be attained if the sense of smell were to be the sole judge of success, and the practice of deodorisation led also to the discovery and use of many substances which have the power to prevent or retard putrefaction, and were therefore termed antiseptics, and regarded as equivalent to disinfectants. The conclusion, however, was soon forced upon the minds of experimenters that the infective agencies of fevers, small-pox, etc., were neither offensive gases nor the products of putrefaction, but something of an entirely different character. When an infectious disease became associated with

the idea of a transportable material which increases and multiplies in its new ground, the discovery was not far off that organisms capable of reproduction are the real causes of the disease.

Definite ideas now prevail as to what is meant by disinfection, and as to the methods by which this object can be attained and the tests whereby their efficacy may be proved. Any substance may be regarded as a true disinfectant which, when added to a quantity of fluid swarming with bacteria, abolishes the reproductive power of these organisms. If the bacteria are capable of producing disease, or the poison of disease, a successful experiment has been made in the way of disinfection. This fact explains the paucity of the real experiences we possess of disinfection proper. Heat, exposure to air and sunlight, removal by mechanical processes, and the use of chemical agencies, are the means at our disposal; it will be sufficient to point out a few of the methods in which they may be employed.

A very high temperature, say of 240° and upwards, will, of course, destroy all such forms of organised matter as we are now considering, and if we could always isolate the germs of disease and

expose them to great heat, the task of disinfection would be thoroughly accomplished. Such isolation is of course impossible, but we make use of heat for the destruction of germs which have found a resting-place in clothes, bedding, and textile articles of furniture. The application of heat requires apparatus which cannot be extemporised, and which are indeed beyond the capacity of private resources. The infected articles have to be placed in ovens or hot-air chambers, the temperature of which can be raised many degrees above the boiling-point of water. A high temperature, however, has less effect upon the spores than upon the mature organisms, but successive heatings are found to effect the desired result. During their development, which is much promoted by the influence of heat, the spores rapidly pass through several stages, in which they become softened and far more capable of final destruction. Exposure to a current of steam at a temperature of 212° is a more potent, rapid, and satisfactory method than the use of dry heat, and it has the further advantage of causing less injury to the articles to be disinfected. This question of injury to infected articles is of much importance in dealing with poor patients; but

under different circumstances, or when the articles are of small value, complete destruction by fire is the best means of disposing of them. In the majority of cases, and especially when the articles consist of blankets and other woollen goods, destruction has to be avoided, and the problem to be solved is how to disinfect thoroughly and at the same time do as little damage as possible to the textures. Those materials which are derived from the animal kingdom are the most expensive and the most difficult to deal with, and are at the same time the favourite resting-places of the germs of disease, which when contained in woollen materials, are protected from currents of air and thus preserved. As Dr. Russell, the Medical Officer for Health for Glasgow, points out, "The value of the manufactured article depends sometimes on form and elasticity, which may be lost through heat; or on colour, which may be impaired. Every one knows that blankets and other woollen articles cannot be boiled without serious injury. Even the most cautious washing changes gradually the white, fleecy, new blanket into the yellow, dense, bare, comparatively comfortless old one. With cottons and linens there is no trouble. They may be boiled with impunity.

Wool, hair, and feathers are most troublesome. They all depend, for their value and utility, upon form and elasticity, which again depend, not only upon the hygrometric moisture, but upon the presence of certain fats. When we begin to deal with such articles, we find that we are involved in all the technical knowledge of several trade processes. . . . The practical result is constant friction in carrying out disinfection; temptation to public officials to scamp the work to avoid censure; constant private efforts to escape interference by concealment, or appeal to fictitious domestic processes; or on the part of the wealthy to resort to the general cleansing and renewing operations of the upholsterer and hair and feather cleaner."

If we wish to popularise disinfection, we must simplify the process as much as possible, having due regard to efficiency. It must never be forgotten that exposure to sunlight and fresh air constitutes one of the most effective means of disinfection that we possess, and it has the great advantages of involving no expense and but little trouble. Accordingly we find that in all regulations, intended to be observed by the public in general, great stress is laid upon the employment of those

great natural disinfectants, fresh air and sunlight. Additional measures, easily carried out, should either precede or follow the exposure to air. Clothes, bedding, and all textile fabrics should be thoroughly washed with soap and hot water, left to soak for some hours in clean water, and then dried and exposed to air and sun for as many days as possible. Such articles as cannot be washed should be fumigated, in a manner presently to be described, either with chlorine or sulphurous acid, well shaken, beaten or brushed, and exposed freely for several days to sun and air. As a matter of course, all pillows, beds, mattresses, stuffed furniture, etc., should be cut open, the contents spread out and thoroughly fumigated. "Carpets are best fumigated on the floor, but should afterwards be removed to the open air and thoroughly beaten."

Dr. Russell states that at Glasgow, simple washing has for many years been the sole method of disinfection applied by the sanitary authorities to all washable articles, and that the most careful investigation has failed to discover a single case of disease propagated by such materials. As a matter of course, every care is taken that the work is thoroughly done; the washing-house is constructed

for the purpose, and provided with an ample supply of water and steam, and various mechanical appliances. All articles, with the exception of woollen fabrics, are purified by boiling or exposure to steam at a heat of 212°. Owing to the extreme softness of the water and the copiousness of the supply, Glasgow doubtless has many facilities for carrying out a system of disinfection which is, to a great extent, mechanical in its operation. Beating, shaking, and brushing are valuable auxiliaries in dealing with articles which cannot be properly washed.

For the disinfection of the air of rooms, many substances are recommended and employed, but the way in which they are generally used causes them to act merely as deodorants. Even at the present day the fact is very incompletely realised that ventilation — that is, the continual admission of fresh air, coupled with the escape of air that has been contaminated—is the only effectual method of purifying the atmosphere of rooms occupied by patients suffering from infectious diseases. It is simply useless to place saucers containing chloride of lime, carbolic acid, or Condy's fluid in a contaminated atmosphere with the expectation that the

germs floating about therein will be attracted, caught, and killed, like mice in a trap. The chlorine, doubtless, will readily diffuse itself throughout a room, and remove some offensive odours; but to act as a true disinfectant it must be so much concentrated, that the air thus charged with it would be quite irrespirable by human beings. It is, however, when used scientifically, the best disinfectant we possess for purifying the walls, etc. of an empty room. All the openings and chinks of such an apartment should be made as nearly air-tight as possible, and the evaporation of a large quantity of water in the room aids the action of the chlorine, which is easily generated by adding hydrochloric acid to bleaching powder.

If, however, large quantities are required, these are most readily and economically obtained by pouring two parts of sulphuric acid, of a specific gravity 1·535, over one part of bleaching powder, just enough water being then added to cause the latter to be covered. The gas may also be prepared in another way, viz. by mixing together common salt four parts, oxide of manganese three parts, sulphuric acid nine parts, and five parts of water. This process involves more expense and trouble

than the method with bleaching powder. When chlorine is used for fumigating and disinfecting purposes, the vessels containing the mixture which evolves it should always be placed in the higher parts of the room, as it then descends on account of its density, and soon becomes mixed with the surrounding air. It must be remembered that chlorine when combined with moisture removes many vegetable colours from fabrics; it has little, if any, bleaching power when moisture is absent.

For *deodorising* purposes in sick-rooms and passages, a gas called "euchlorine" will be found very serviceable. It is produced when a few crystals of chlorate of potassium are dropped into a little hydrochloric acid. The mixture can be conveniently made in a small wide-mouthed bottle, which should be placed as near the ceiling as possible so that the gas may descend into the room. Half-an-ounce of the strong acid will be found sufficient for several days; a few crystals of the chlorate, as many as can be taken between the finger and thumb, should be dropped in night and morning.

Bromine is even more powerful as a disinfectant than chlorine, but is not so convenient for use;

both these agents are superior to sulphurous acid, which, however, possesses a considerable degree of efficacy, and is easily employed for disinfecting empty rooms. All openings and chinks should be closed as before, and a pound or more of sulphur should then be burnt in a brazier or other suitable vessel. The space to be disinfected should be kept saturated with the gas for a couple of hours or more. It must be remembered that sulphurous acid tarnishes and damages metals, and bleaches vegetable colours.

For the disinfection of walls and ceilings Professor Esmarch recommends that they should be rubbed down with bread, the pieces of which must be carefully collected and burnt. Experimenting in this way in the Berlin Hygienic Institute, he found that all germs were completely removed, and the rooms were rendered immediately habitable without danger. The rubbing is easily effected, and can be done at very little expense by untrained persons; it may also be used as a preliminary to disinfection by chlorine or sulphurous acid, both of which will penetrate into chinks and corners which cannot be reached by the hand.

Washing the surfaces by means of a spray

containing disinfectants in solution is another efficacious method of purifying walls and ceilings, and the most potent substance which can be used in this manner is the perchloride of mercury or corrosive sublimate. The solution, which is highly poisonous to all forms of life, contains one part of the mineral in one thousand parts of water. A similar solution may be employed for the immersion of infected linen or clothing, before washing; the articles should be allowed to remain in it for four hours at least.

Carbolic acid has been much overrated as a disinfectant. The spores of the micro-organisms discovered in cases of splenic fever have been found to be absolutely unaffected after lying for upwards of three months in a five per cent. solution of carbolic acid in oil. It has also been found that vaccine matter mixed with carbolic acid in solution still retains its efficacy, and the question may therefore well be asked whether the highly diluted carbolic vapour used for purposes of aërial disinfection is not powerless to deal with an atmosphere saturated with the germs of infectious diseases. For the disinfection of liquids, a large amount of carbolic acid is required; the

mixture should contain at least two per cent. by weight of the pure agent. Carbolic vapour will preserve for some months the freshness of a piece of meat suspended therein, and a very small quantity mixed with animal fluids keeps them fresh, and prevents all tendency to decomposition for an almost indefinite period. Milk can be thus preserved by the addition of one-fifth per cent. Carbolic acid will stop the progress of putrefactive changes, and, as Dr. J. A. Russell points out, "small quantities of this disinfectant, instead of destroying contagion, may actually preserve its activity, when otherwise it would have succumbed to the action of natural agencies. This danger may accompany the limited use of any disinfectant that has a 'pickling' or preservative action in small quantity." There is also another drawback connected with its use. Volatility is one of its properties, and "the acid may, for a time, deprive the contagion of its infective power, without permanently abolishing it, and the virulent properties may be regained whenever the acid has evaporated."

Condy's fluid, a solution of the permanganate of potassium, is much employed for general purposes of disinfection and deodorisation. It is a

very efficacious deodorant of fluid matters, and has the advantage of being non-poisonous; but to act as a real disinfectant, that is, to destroy contagious germs or abolish their power of reproduction, it must be used in very large quantities and is therefore expensive. It is admirably adapted for deodorising offensive matters in the sick-room, and to these it should be added until its colour remains. It is likewise well adapted for pouring down drains and sinks, and a supply of it should be kept in every house. Ozone may be prepared from it by adding three parts of strong sulphuric acid to two parts of the salt dissolved in water, and this, like the permanganate itself, oxidises organic matter and thus destroys offensive emanations, and, moreover, being gaseous, will diffuse itself through the air, whereas the permanganate is non-volatile. Ozone is also evolved from terebene, which is a very effective and pleasant deodorant when used with a spray apparatus.

For the disinfection of sinks, drains, etc., the permanganate has already been advised; carbolic acid and the chloride of zinc (Burnett's solution) are also efficacious. A perchloride of mercury solution, eight grains to a gallon, is an extremely

powerful disinfectant, but the mercury is precipitated when brought into contact with copper, lead, and tin, and it renders leaden pipes very brittle. The stronger acids are liable to objections of the same character.

Some of the statements made in preceding paragraphs will now be summarised, so as to indicate the methods of carrying out disinfection under the various circumstances in which it is required.

A patient suffering from a contagious disease must be prevented from becoming a source of danger to the healthy. Infective matters are being constantly given off from his body, and every care must be taken to prevent these from being conveyed to others by attendants, by clothes, bed-linen, etc., or through discharges of all kinds. Free ventilation into the open air through windows provides for the escape of noxious emanations, which are rendered harmless by dilution. After recovery, the patient, nurses, all clothes, the sick-room and its furniture must be thoroughly disinfected.

The measures best calculated to ensure these objects are as follows:

1. The patient must be isolated in a separate room, at the top of the house, if possible. All unnecessary articles of furniture, woollen materials especially, must be removed from the room before the patient is placed in it. Carpets and woollen curtains are favourite resting-places of morbid germs, and are disinfected and cleansed with difficulty. All drawers, cupboards, etc., should be emptied. Staircase windows should be kept open night and day, so as thoroughly to ventilate the house. The door of the patient's room must be kept closed as much as possible, and outside should be suspended a cloth saturated with a solution of carbolic acid, chloride of zinc, or with dilute Condy's fluid. This should never be allowed to become dry. The windows in the room must be kept open whenever circumstances will permit, and except in hot weather a fire should be kept burning. The destruction of unpleasant odours is best effected by euchlorine (see page 39). The patient's attendants should not visit other parts of the house, and it will be an advantage in most cases to select persons who have already had the disease. The medical attendant will adopt all necessary precautions to prevent himself from becoming a carrier of con-

tagion. With regard to the residents in the house, there is no risk in allowing them to continue their ordinary avocations and to leave the premises as usual, provided that the patient is kept properly isolated, and plenty of fresh air is allowed to circulate in the house. Vessels, cups, and plates used for feeding the patient should be kept upstairs, and articles of food or drink left by the patient should be destroyed.

2. All the discharges from the patient should be disinfected before being carried downstairs. If they are to be thrown into the drains, the best disinfectants are carbolic acid, chloride of zinc, and permanganate of potassium. These should be freely employed; small quantities are utterly useless. Whenever the discharges can be buried deep in earth (an excellent method of disposing of them) quicklime should be added in excess, or a strong solution of perchloride of mercury (four grains to a pint of water) should be mixed with them. In country places where fuel is readily procurable, burning the discharges in the open air is an excellent way of destroying contagious germs.

3. For disinfecting the sheets and body-linen used by the patient, the methods already described

must be carefully employed (see page 36). As soon as the clothes are removed from the patient or his bed, they should be placed in a wooden tub containing a solution of perchloride of mercury (two grains to a pint). After remaining for twelve hours, they may be removed, rinsed in clean water, and sent to be washed.

4. When the patient is convalescent, he should be carefully washed with hot water and carbolic or thymol soap, and as soon as he is able to bear them, a few warm baths will have a very beneficial effect. His hair should be thoroughly cleansed, and he should be dressed in clothes which have not been in his room, and taken into another apartment. The attendants should adopt similar precautions with regard to washing, change of clothes, etc.

5. The room, when vacated by the patient, should be thoroughly cleansed and disinfected. All movable articles should be taken away, washed, exposed to heat and then to air and sunlight. Especial care is necessary in dealing with bedding, wool and feathers. With regard to the room itself, the best means of disinfecting it have been already described (see page 37). Chlorine and sulphurous acid are the best gaseous disinfectants, and are

easily generated. The floor should be thoroughly scrubbed, the ceiling scraped and whitewashed, the walls repapered or rubbed over with bread, and the paint washed with carbolic soap. It is impossible to take too much pains in carrying out these measures of disinfection. After they are completed, the windows and door of the room should be left open night and day for a fortnight at least before the room is again occupied.

It is quite certain that the germs of some infectious diseases, notably cholera and typhoid fever, are conveyed into the human body through the medium of drinking-water. When compelled to make use of water of a suspicious class, filtration and boiling constitute the most reliable methods of purification. Spongy iron is, upon the whole, the most efficacious filtering material. The water, especially if passed through sand afterwards, comes out quite clear and pure, and may be kept for a long time without showing any signs of the production of living organisms. Charcoal filters, on the other hand, certainly sometimes allow spores or germs to pass through unchanged, and when they are employed, boiling should always be superadded. It is not sufficient to bring the

water once to the boiling-point; in order to be efficacious repeated boilings are necessary, for the reasons given in a preceding paragraph. Milk of a suspicious character should always be thus thoroughly boiled. Travellers on the Continent do well to provide themselves with small portable filters, now easily procurable, for in many places the drinking-water is highly charged with impurities. It is satisfactory to know that the tannin contained in tea is a purifying agent of some value as regards organic matter present in water.

In order to complete this sketch of the present state of our knowledge with regard to infection, and of the best methods of preventing the spread of infectious diseases, it seems desirable to give a short account of the public arrangements having the latter object for their aim. In the metropolis every vestry and district board must appoint one or more legally qualified medical practitioners of skill and experience as officers of health. The duties of such officers are, among others, to ascertain the existence of diseases, more especially epidemics, and to point out the best means of checking or preventing their spread. Under the Public Health Act, 1875, the whole of England,

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with the exception of the metropolis, is divided into sanitary districts, placed under the charge of certain authorities, who must appoint, from time to time, a medical officer of health, whose duties have been clearly defined by the Local Government Board. We have, therefore, at the present time, in every part of the country, highly-trained medical officers of health, performing duties of a manifold character, having for their objects the prevention of the breaking-out and spread of disease, and the improvement of the general health of the public at large. It is not too much to say that the efficient performance of these duties, aided by the co-operation of those most nearly concerned, cannot fail to lessen the number of cases of infectious disease, and might indeed, in time, cause some of these affections to disappear from the Registrar-General's returns. One of these duties is described in the following regulation: "On receiving information of the outbreak of a contagious, infectious, or epidemic disease, the medical officer shall visit the spot, inquire into the causes and circumstances of the outbreak, advise as to measures for preventing the extension of the disease, and assist in executing the same."

The medical officer cannot act without information, for which, in the large majority of cases, he must depend upon others, and the questions then arise: Who is to furnish the information, and should the reporting be made compulsory, that is, should penalties be attached to neglect in this respect? There is much division of opinion on these two points, which ought to be definitely and promptly decided, for of the various attempts recently made to arrest the spread of infectious disorders, the measures which provide for their compulsory notification to sanitary authorities are by far the most important.

Up to the present time Parliament has dealt with the subject of the notification of infectious diseases in a manner which is both imperfect and unsatisfactory. It has laid down no general principle applicable to all communities; but has simply permitted regulations on the subject to be inserted in a few local Bills. Hence it happens that in most places it is no one's business to report the existence of cases of infectious disease to the sanitary authorities; in others, the medical attendant is charged with this duty, and neglect to perform it is visited with a penalty; and in

yet other instances, a similar duty is likewise imposed upon the householder, a dual notification being therefore requisite. Each of these plans has its advocates. The advantages of notification cannot be doubted; but it is surely absurd to enforce the practice in one place and to neglect it in another, where perhaps much benefit would result from its introduction. As forcibly expressed by *The Lancet* on a recent occasion: "If it is wrong for a tailor in Edinburgh to suppress the fact that he has scarlet fever in his house, it must be wrong for a tailor in London to do the same; and if a tailor in Kensington is allowed to keep such a fact to himself, as one with which the public may not intermeddle, then the tailor in Edinburgh, who is bound to notify the same to the sanitary authorities, has good reason to complain of inequality of laws." No one at the present day will seriously assert that any plea of individual rights can be advanced when the well-being of the community is at stake. One English town has expressed a very clear opinion on the subject of notification and the practical results that should follow, and it is not a little curious that the same community should have made itself notorious by its opposition to com-

pulsory vaccination. At Leicester, whenever small-pox appears in a family, the authorities vaccinate all but the actual patient, and remove them to a place of seclusion, where they are isolated from the outer world. It is asserted that the adoption of this plan enables the authorities to dispense with the compulsory vaccination of infants, which is regarded by them as a grievous and needless infringement of personal rights.

A Bill to secure notification is at the present time before the House of Commons, and the only points really at issue refer to the person upon whom the duty of notification should devolve, and the question whether such duty should be compulsory. The medical attendant is obviously the only person really competent to report the fact that a case of infectious disease exists in a given house; it is his duty to discover the nature of the complaint before he can properly treat it. For some days (as, for example, in many cases of typhoid fever) he may be in doubt as to the real significance of the symptoms; but, sooner or later, their true nature becomes apparent, and, as a general rule, is explained to the patient's friends. If the latter alone are to be charged with the duty of making the report, after hearing a verbal

statement from the medical attendant, errors and misunderstandings would constantly occur; many persons would shirk reporting altogether, others would make incorrect or imperfect statements. It does not seem fair to the medical attendant, to force him to send in a written notice to the authorities, and to punish him for neglect, and it is certainly unnecessary to insist on a dual notification, inasmuch as the friends can only repeat the statements made to them by the doctor. It appears to the writer that the difficulty might be solved by requiring the medical attendant to furnish the patient's friends or the householder with a certificate, setting forth the nature of the illness; that the friends should be required, under a penalty for neglect, to send the certificate to the sanitary inspector, who should acknowledge its receipt to the medical attendant, and forward him a small fee, say half-a-crown. If the doctor considered that the patient's friends would do all that was necessary in the way of disinfection when the proper time came, the sanitary authorities would take no further action in the matter; but their aid would be solicited whenever the doctor had reason to believe that the friends were either unwilling or unable to disinfect the premises in

a satisfactory manner. This plan would appear to be free from the objections raised against charging the medical attendant with the duty which clearly ought to belong to the householder. The public at large should be made to feel that every one is interested in preventing the spread of infectious diseases. Of course there are many persons who would, from various motives, suppress information, and keep back any certificate. Such neglect, however, could not exist without the knowledge of the medical attendant, who would warn the offenders of the consequences of disobeying the law.

I must not bring this essay to a conclusion without stating that there are many disinfectants now offered to the public, but which regard to space and the purpose I had in view have prevented me from describing. I have thought it best to confine my remarks to such disinfectants as are really efficacious, and to point out the advantages and drawbacks connected with their use. With respect to many so-called "disinfectants," it is sufficient to say that their power has been absurdly over-estimated. It cannot be too strongly insisted upon that deodorisation is by no means

equivalent to disinfection. My object has been to indicate in the first place what in the present state of our knowledge seems to be the true theory as to the causation of infectious diseases, and to show how obstacles are presented to more rapid scientific progress by the extreme minuteness of the organisms with which we have to deal. With regard to disinfection, I have striven to prove how entirely it must depend for its success on the specific action exercised upon the disease-germs by the means employed. The realisation of this necessary relation cannot fail to dispel many a fond belief with regard to disinfectants; but it will leave us with a more intelligent and useful appreciation of their true properties, and by revealing how far we still are from the goal of complete knowledge, may even stimulate the investigator to explore paths of science which are yet unknown. Virgil says, "Felix qui potuit rerum cognoscere causas," and to nothing is this aphorism nowadays more applicable than to a knowledge of those agencies which produce infectious diseases.

THE END.

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